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UNITED STATES
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BUREAU OF MINES
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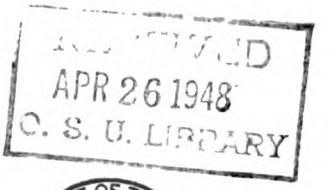
UNDERGROUND METAL-MINE FIRES FROM CUTTING AND WELDING



BY

ALLEN D. LOOK

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UNDERGROUND METAL-MINE FIRES FROM CUTTING AND WELDING[1]

By Allen D. Look[2]

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INTRODUCTION

Underground fires often prove difficult to control, and a small fire can quickly grow into a large one, endangering life and causing large property damage. Even a small underground fire may produce enough noxious gases to cause suffocation; therefore, every precaution should be taken to prevent and control such fires. It is ironic that mine fires should be caused when utilizing materials that are in themselves fire-resistant; yet, cutting and welding of iron and steel are proving to be common causes of underground fires in metal mines. This paper includes 19 examples of underground fires of this nature, and undoubtedly this is only a fraction of the number of similar fires that have occurred in the last few years. This paper will review some metal-mine fires caused by cutting or welding and point out precautions to be taken to prevent other fires from this cause.

1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Inf. Circ. 7453."

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Cutting and welding operations are usually conducted underground in a well-ventilated fire-resistant area especially equipped for the work where fire hazards have been eliminated before the welding or cutting equipment is installed. Likewise, the prevention of welding and cutting fires in surface operations, the importance of personal protective equipment, maintenance of equipment, and the hazards of compressed gases are not mentioned, as these subjects are discussed in numerous handbooks[3/4/] and articles.[5/6/]

ACKNOWLEDGMENTS

Material in this paper was obtained largely from information furnished by personnel of various mines and from reports written by Bureau of Mines engineers. Information on Canadian mine fires was taken from Annual Reports of the Ontario Department of Mines. Much of the information on Arizona mine fires was furnished by Orr Woodburn, director, Globe-Miami District Mine Rescue and First Aid Association. Especial acknowledgment is made of the assistance given by Frank E. Cash, supervising engineer, Bureau of Mines, Duluth, Minn., and E. H. Denny, supervising engineer, Bureau of Mines, Salt Lake City, Utah.

SOME UNDERGROUND FIRES FROM CUTTING AND WELDING

Arizona Copper Mine

A fire was started in a large copper mine when several steel I-beams in contact with timbers in a heavy-timbered section were cut with an oxyacetylene torch to facilitate caving. The area was wet down with a soda-acid fire extinguisher on completion of the work during the day shift, but a fire was discovered at the start of the day shift the next morning. The fire was extinguished by direct use of water from hose.

In this case, the fire smoldered several hours before becoming noticeable, as a fire patrol through the area on the following shift did not detect anything amiss. Prompt discovery of the fire as soon as it started spreading aided in its extinguishment by direct methods without a great deal of property damage.

Some time before, at the same mine, men had been driven from the vicinity of an intake shaft by smoke from a small fire resulting from use of an oxyacetylene torch for repair work in the head frame. The shaft was covered with steel doors before a cutting torch was used, but burlap was employed to close the openings around the guides. Hot metal ignited this burlap, and the consequent smoldering sent considerable smoke down the shaft. There

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3/ The Linde Air Products Co., Preventing Welding and Cutting Fires: New York, 15 pp.

4/ American Welding Society, Welding Handbook: New York, 1942, pp. 1057-1062.

5/ Safety Engineering, Safety Code for Welding, Burning, and Heating: Vol. 91, February 1946, pp. 22-26.

6/ Occupational Hazards, Watch Those Welding Sparks: Vol. 9, June 1947, pp. 45-47.

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was no property damage, and no harm resulted except for the loss of time of the men driven out of the mine. This case, however, does point out that all parts of the shaft covering should be fire-resistant.

Arizona Metal Mine

In 1945, a fire in an Arizona metal mine was caused by the use of a cutting torch while a skip was being repaired during the lunch period. The skip was at the shaft collar, and hot metal from the cutting operation caused a fire at a level station 200 feet below. Three boxes of explosives, which had been placed at the station for transportation to the lower levels, were ignited and burned. Lack of timber kept the fire from spreading in the mine, and the timbered shaft was saved by means of water from a surface fire hose.

No fire-preventive steps were taken before the repair work was begun. The presence of explosives at the station was due to a misunderstanding of orders, as ordinarily such delivery was made during the latter part of the shift.

Arizona Mine-Shaft Fire

A costly fire destroyed the shaft timbers, hoist-compressor house, ore bins, crusher plant, and storeroom of an Arizona metal mine and resulted in 3 months' loss of production. Welders had been working on the cages at the collar of the shaft; and about an hour after they had ceased work, smoke was noticed coming out of the shaft. By this time, the fire was burning with enough intensity to change the normally downcast air current to upcast. Water poured down the shaft did not check the blaze, and it was several days before the fire was extinguished. No precautions had been taken to prevent sparks from falling into the shaft.

Arizona Copper Mine

A cutting torch was used in making emergency repairs to a skip at the shaft collar of a large copper mine in 1946. In the belief that the concrete shaft offered adequate protection, no covering was placed over the shaft. Hot metal or sparks ignited a wooden guide some 50 feet below the collar. In this case, the fire was soon discovered; and a man, lowered on the skip, was able to put out the fire with a hand extinguisher.

Abandoned Shaft

In 1941, steel scrap was being recovered in the vicinity of the abandoned "K" shaft at the Old Dominion mine, Globe, Ariz. Sparks from an oxy-acetylene torch started a fire in the shaft about 30 feet away, and two sets of timbers were burned out before it was extinguished by personnel and facilities of the Globe-Miami District Mine Rescue Station. Although not in production, the mine is still an essential source of water for other large operations in the vicinity.

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California Gold Mine

An underground fire was cuased in a California gold mine when an oxy-acetylene torch was used to make some changes in a 4-inch air line. The welding crew finished the job of cutting and changing the air line on Sunday, and early the next morning a fire was found burning where the work had been done. Although the fire could be fought directly with a 3-inch fire hose, considerable drift timber was burned, and the fire spread to an adjacent raise before being extinguished. It is believed that hot metal or sparks, dropped during the work, caused a smoldering fire, which was unnoticed at the time but blazed up after the crew had left.

Iron Mine

Repairs to a cage at an underground iron mine necessitated use of an oxyacetylene torch at the collar of a supply and ventilating shaft. A piece of hot metal fell into the open shaft and ignited timbers about 40 feet below the collar. The fire was extinguished with water after endangering the lives of several miners.

Michigan Mines

A shaft fire was discovered several hours after workmen had used a cutting torch to salvage metal from cars near the shaft on three different levels. This fire resulted in the asphyxiation of one workman and considerable loss of production.

About a year earlier, another fire had been started at this mine by hot metal dropping down a shaft while a cutting torch was being used to salvage scrap metal from the surface plant.

In a 2-year period, four other fires were started in Michigan shafts by sparks or hot metal during cutting or welding operations. The fires were quickly discovered and extinguished with fire-fighting equipment, which was readily accessible. A fifth underground fire was discovered and extinguished under similar circumstances when sparks from a welding torch ignited grease on a rotary-dump bearing.

Colorado Metal Mine

A fire was started in raise timbers when some adjacent rail spiling was cut with an oxyacetylene torch in the course of a Sunday repair job. Water was first thrown on the fire by hand until it was thought to be extinguished. Later the same day, the fire flared up again, and it was extinguished only after pumps were installed to furnish water at both the top and bottom of the raise.

Canadian Mines

A cutting torch was being used to cut pipe supports during retimbering of a winze when sparks or molten metal set fire to dry blocking. Two 1-quart

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carbon tetrachloride fire extinguishers carried as a precautionary measure were used without effect. Then an attempt was made to connect a water hose about 40 feet from the winze, but smoke from the fire drove the men away. All men were evacuated from the mine, and a short time later from an adjoining mine. Mine rescue teams were used for fighting the fire, which had started on July 3, 1946; recovery operations were completed 6 days later. Besides loss of production, the fire destroyed 125 feet of winze timber and the timber in an underground hoist room. Several tons of loose rock fell in the winze and hoist room.

Another Canadian mine fire was started when an oxyacetylene torch was used to strip iron from a chute. There was no sign of fire when the men left at 3:30 p. m. About 5:30 p. m., an odor of burning wood was noticed, and it was found that the side of the chute and adjacent timber were ablaze. The fire was extinguished with portable extinguishers and water hose.

A third fire resulted when a shaft hanging rod was being cut in the course of some shaft repairs. The flame of a cutting torch ignited the top of a post in the shaft timber, which smoldered for 2 hours before starting a small fire. The fire was extinguished by a fire extinguisher.

DISCUSSION

From the afore-mentioned examples, it is evident that underground fires, following cutting and welding, have been caused by combustible material being in contact with the molten metal dropping from the cut, by sparks, by the heated metal being cut, and by the oxyacetylene flame itself. Separation of combustible material from the source of ignition will prevent fire and can be done either by moving the work to a safe place or removing the combustible material for a safe distance around the operation.

Fires have resulted in places thought to be a safe distance from the welding operation. From a published chart it is seen that, dependent upon the pressure, sparks from a cutting blowpipe will bounce a considerable distance.7/ With the cutting 7 feet above the ground, these distances are given as follows:

Pressure, pounds per square inch	Distance sparks will carry, feet	Distance sparks will bounce, feet	Total distance, feet
35	11	5-1/2	16-1/2
70	14	12	26
100	16	18	34

Unfortunately, it is not always possible to provide ideal conditions of fire prevention in mines where work must be done in timbered workings. In such cases, the area should be well-wetted down before the work is begun. Sparks should be confined by means of metal or asbestos guards, or fire-resistant curtains arranged so that sparks cannot pass underneath or through openings. A bucket filled with sand or water should be used to catch molten metal where this hot metal could cause a fire. A suitable guard, preferably

7/ Safety Engineering, Welding and Cutting Fire Control: Vol. 90, October 1945, p. 43.

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asbestos, should be used where the blowpipe flame might contact combustible material. Someone besides the welder should watch for fires.

Preparations should be made to extinguish any fire that might start, and the preparations should be in proportion to the fire hazard present. All portable welding outfits should have a fire extinguisher or extinguishers as part of the equipment, and the welding crews should be trained in their use. Owing to the harmful gases sometimes formed when carbon tetrachloride extinguishers are used on fires, this type of extinguisher should not be used underground except in well-ventilated places.

Many of the underground fires caused by cutting and welding occur in shafts following repair work at or near the collar. When necessary to do such work, the shaft should be covered with a substantial, tight cover of fire-resistant material. Such procedure would serve also as a protection from persons falling into the shaft during the course of the work.

Discovery of some of the underground fires noted was delayed for several hours. In some, this was due to the fire smoldering for some time before blazing up, and in others it was because no one visited the vicinity. The rule advocated in surface work of keeping the welding or cutting area under observation for 30 minutes after completion of the work does not apply to underground conditions. Unless employees are present on their regular duties, any area underground where there is a possibility of fire from cutting or welding should have a fire patrol, at least at intervals, for a minimum of 8 hours after the work is completed.

Care must be taken that a fire is not started by the welding or cutting apparatus itself. Escaping acetylene from a leaky connection or broken hose line might easily catch fire. The hose should be protected from flying sparks, hot slag, kinks, being run over by haulage equipment, or other misuse.

With the use of electric welding equipment the usual precautions in the handling of electric power should be observed. Careless handling of electrode holders or damage to insulation, with resulting short circuits or excessive heating, not only presents a fire hazard but also an injury hazard.

SAFETY RULES AND REGULATIONS

Examples

Rules and regulations for preventing underground fires from cutting and welding are included in some State mine laws and in various company rule books.

The California Industrial Accident Commission has issued the following mine safety order:

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Order 1712. Heating Devices Underground

Fire for heating shall not be permitted underground and torches, acetylene lamps, electric heaters, and candles shall not be left unattended in any mine in the vicinity of wood or other flammable material. This shall not be construed to prohibit the use of torches or heating devices necessary for mechanical repairs, provided such devices have continuous attendance while lighted, and all flammable material within a radius of 5 feet of the work being done has been made wet with water before work is commenced and after the repairs have been finished and a fire extinguisher is near by while the repairs are being made.

One large Arizona copper mine covers the hazard at all locations in its general rules and has the following specific safety rule to cover shaft work:

Burning or Welding in Shaft

1. No burning or welding shall be done in the shaft unless absolutely necessary. Burning shall be done only by the request of the foreman.

2. Precautions when burning in shaft:

(a) Two men shall be present when burning or welding is done.

(b) Wet down area where burning is to be done.

(c) Turn on shaft sprays and use water hose to wet down the shaft below and around the working place.

(d) If possible, place a bulkhead or a sheet of metal or asbestos screen over shaft below the work to prevent hot metal or sparks from dropping down the shaft.

(3) Make sure no hot metal such as a nut or a piece of boiler plate drops down the shaft. Inspect immediately after job is completed to be certain that no fire hazard exists.

Another Arizona mine, where considerable cutting and welding are done underground in the course of installations and repairs, has had no fires from this source since adoption of the following safety rule:

Except in cases of extreme emergency which would make the following procedure illogical, no burning or cutting with an oxy-acetylene torch is to be done either in the mine or within 50 feet

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of any shaft collar or any other mine entry without prior approval having been granted by the mine superintendent or assistant mine superintendent.

In the event such approval is granted, all possible safety precautions are to be taken to prevent the outbreak of fire. Water or fire hose shall be available and the area immediately surrounding the work will be thoroughly wet down, both before the work is done and immediately thereafter. Either galvanized iron, steel sheets or asbestos sheets shall be used so that all slag and sparks can be confined and controlled.

After the completion of such work arrangements must be made for a continuous fire watch for the first 8 hours and a visit for fire inspection at not less than 2-hour intervals for 16 hours thereafter.

Suggested General Rules

The following general rules are suggested as a basis for making specific rules for adaptation to the problems of a particular mine:

1. Take work to a safe location if possible.

2. Where the nature of the work makes it necessary to bring a portable welding or cutting outfit to an underground location, make the place as safe as possible.

   (a) Combustible material which can be moved should be taken to a safe distance.

   (b) Wet down the area for a sufficient distance to protect combustible material from sparks or hot metal.

   (c) Protect nearby combusitble surfaces from contact with the flame by means of fire-resistant shields.

   (d) Provide measures to keep sparks or molten metal from reaching combustible material.

3. Provide adequate fire protection to extinguish any fire started by the operation.

4. On completion of the work, wet down the area thoroughly.

5. Provide for frequent examinations of the area, including the return therefrom, for at least 8 hours.

6. Where cutting and welding are done over a shaft, the top of the shaft should be closed by a substantial, tight, fire-resistant cover.

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7. Cutting and welding should be done only by trained personnel who understand the hazards involved.

8. Cutting and welding equipment should be maintained and used in a safe manner.

CONCLUSION

Promiscuous use of welding and cutting equipment underground at any time or in any place is not safe practice. Preliminary precautions and adequate follow-up in connection with underground cutting and welding operations require a little time and effort; but as long as there is the slightest chance of a mine fire from that source, all feasible precautions should be taken.

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